



**Leaders in parallel software development tools**

# Empowering Modelling and Simulation in the Atmospheric Sciences via Developer-Centric Tools for Heterogeneous Computing Architectures

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# Agenda

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- Introduction
- GPU Debugging
- MIC Debugging
- Petascale Debugging
- Summary

# Challenges for developers

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Scale



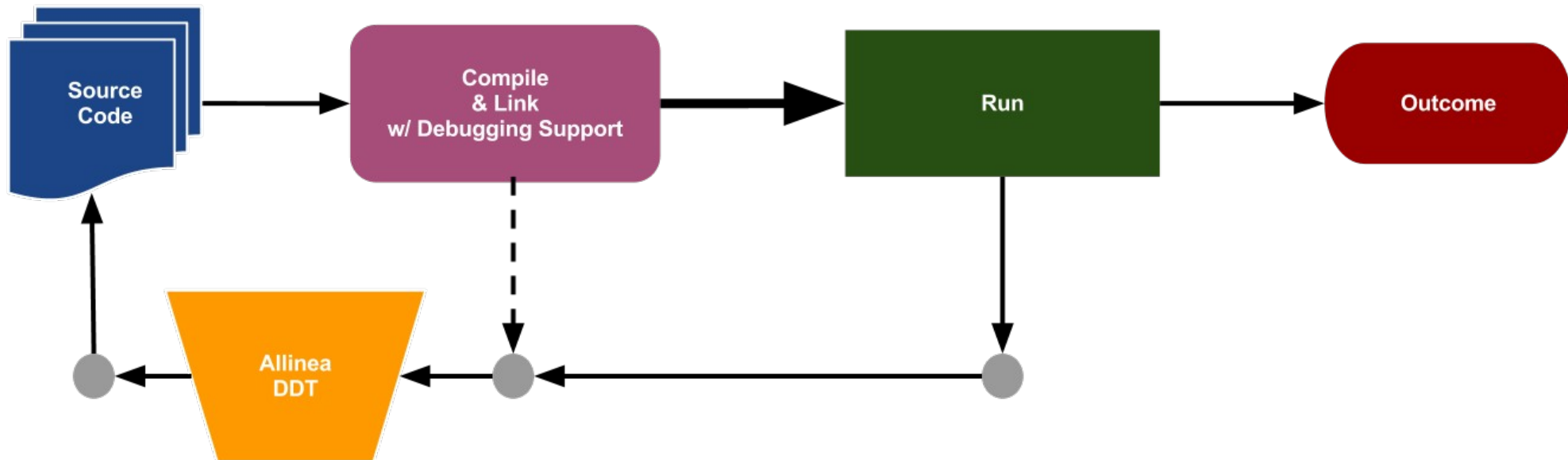
Heterogeneity



Legacy

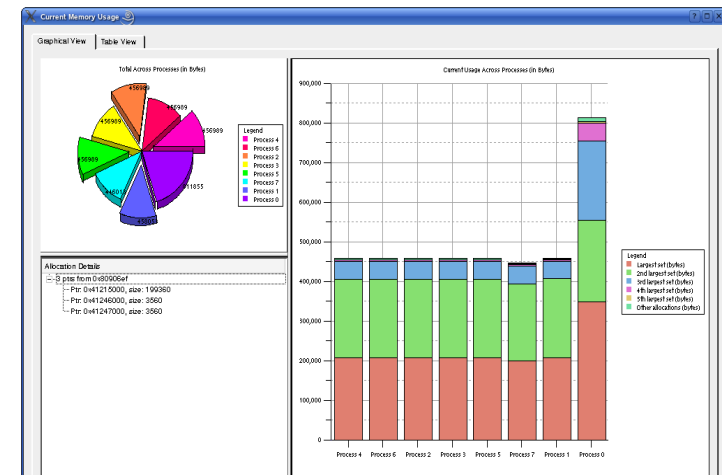
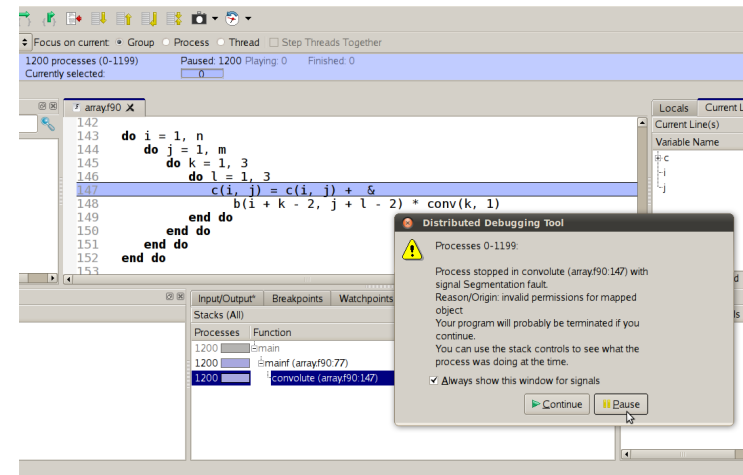
Diversity

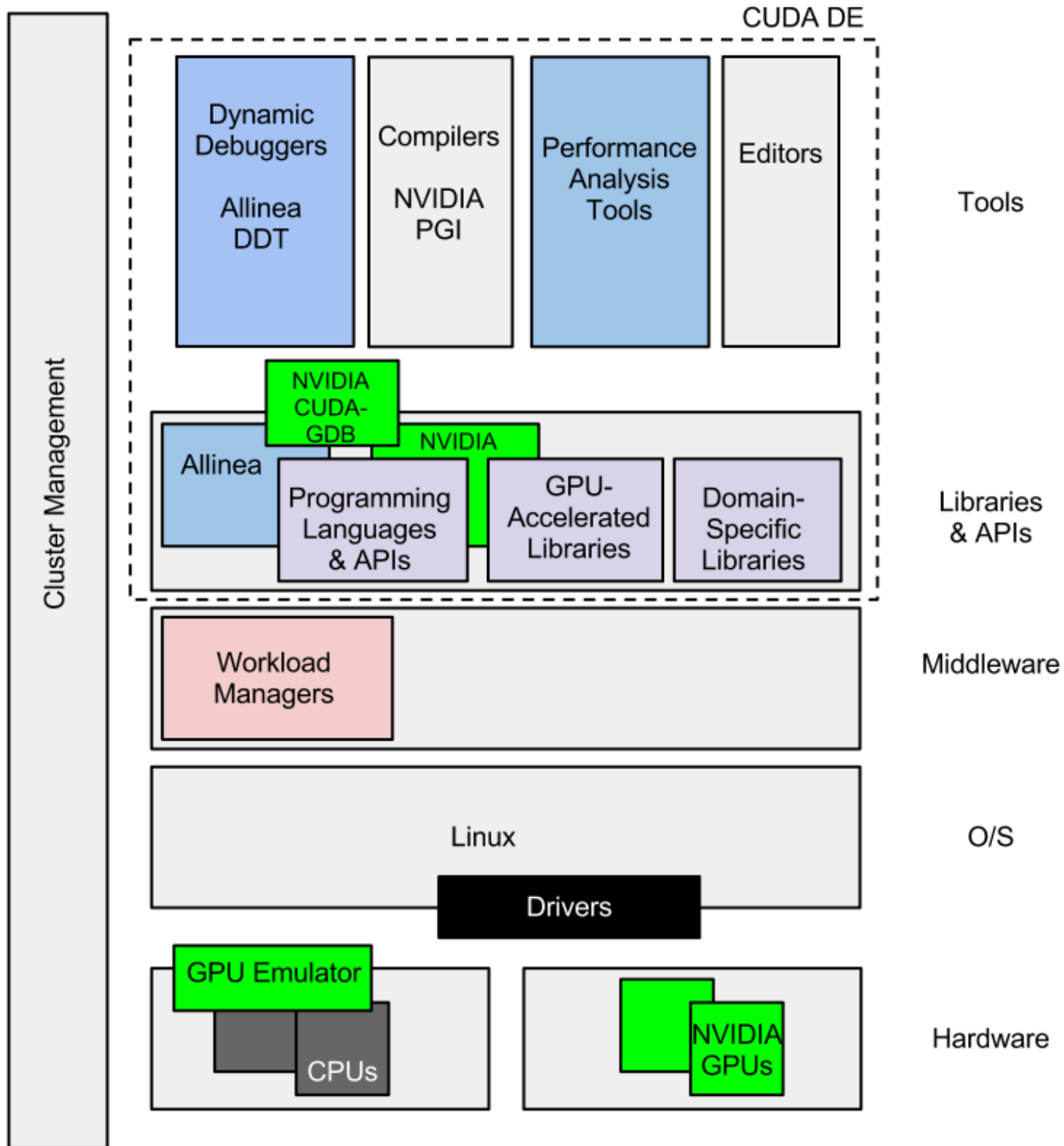
# Dev Process + Allinea DDT



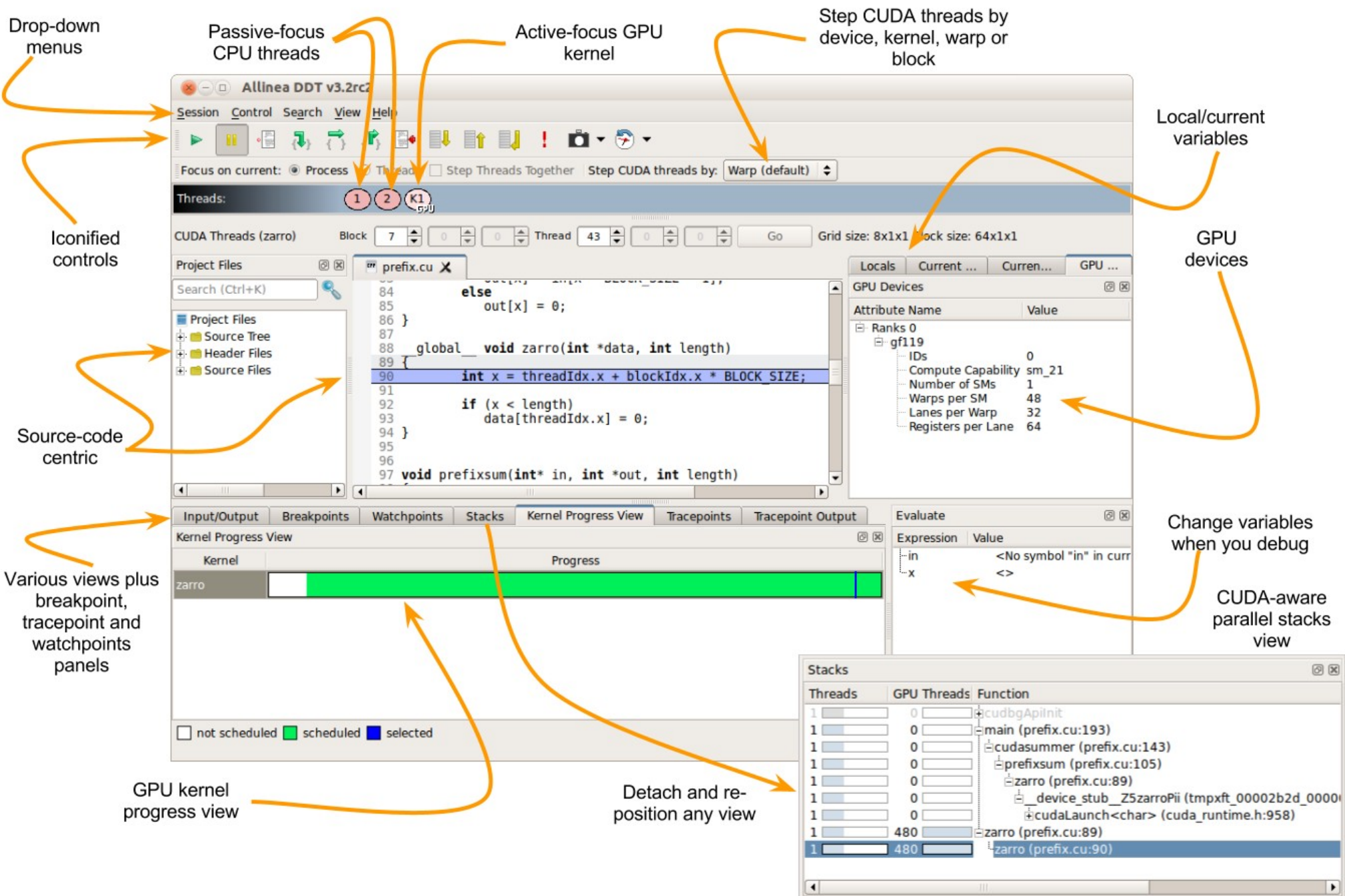
# Alinea DDT in a nutshell

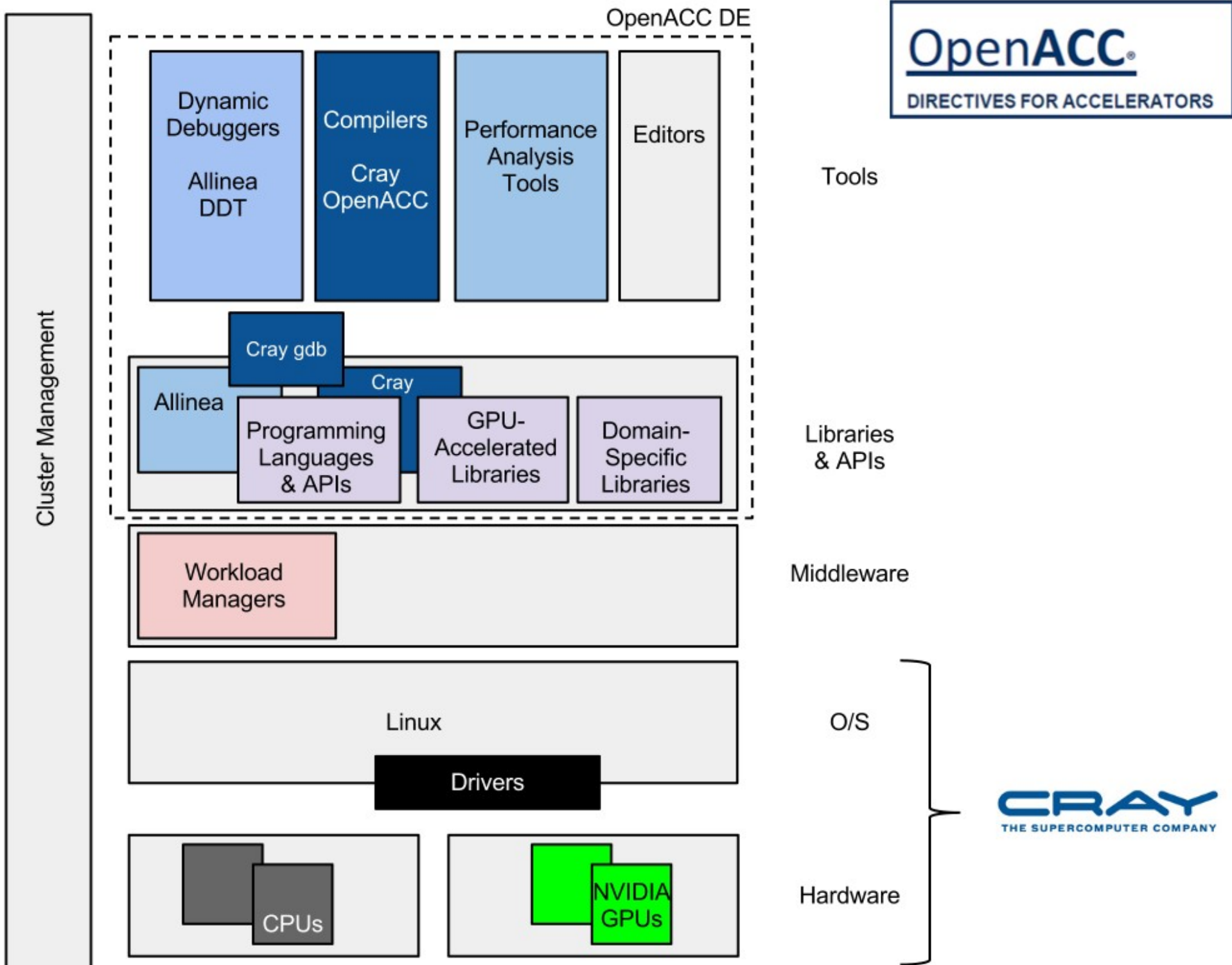
- Graphical source level debugger for
  - Parallel, multi-threaded, scalar or hybrid code
  - C, C++, F90, Co-Array Fortran, UPC
- Strong feature set
  - Memory debugging
  - Data analysis
- Managing concurrency
  - Emphasizing differences
  - Collective control







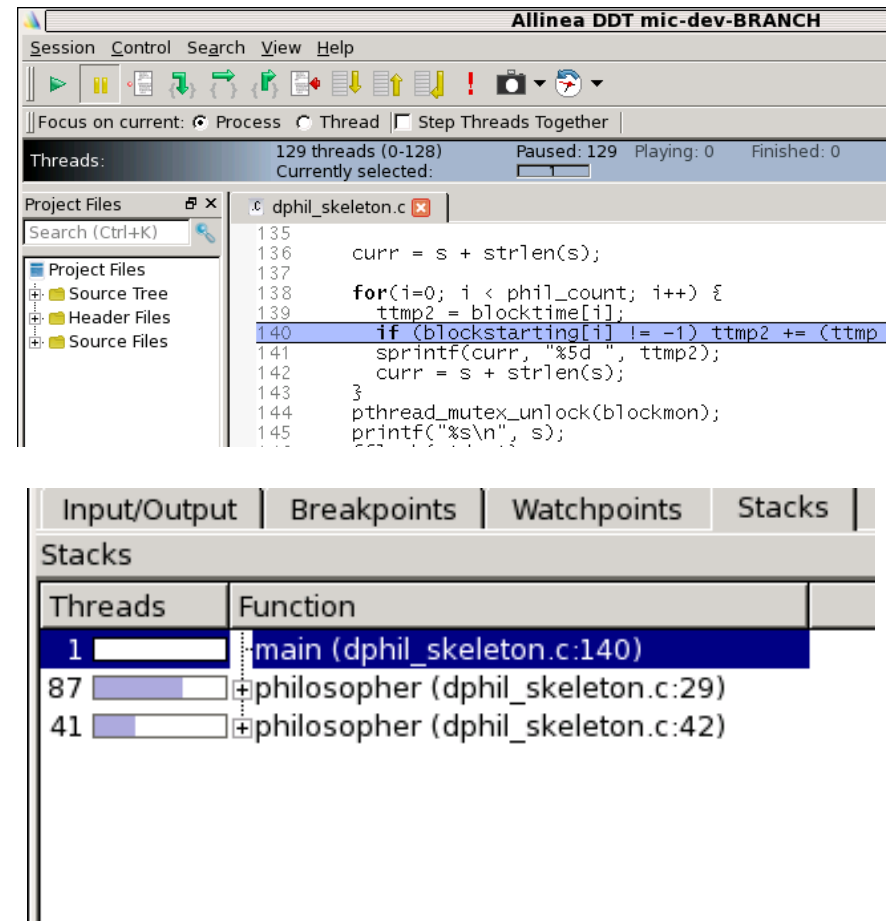






# Allinea DDT on the Intel Xeon Phi

- The same scalable interface
  - Familiar thread control and data inspection
  - All the features of Allinea DDT - including
    - Step threads
    - Examine variables
    - Run to breakpoints
    - Set data watchpoints
- Available for early access partners



# Allinea DDT on the Intel Xeon Phi

## Current Status

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- Under development
  - Fully functional native Intel Xeon Phi support
  - Live demonstrations at ISC
- Early access programme underway
  - Connect to accelerator and host and debug either/both simultaneously
  - Native and symmetric model support
  - Offload model support
  - OpenMP and MPI support

# Usage Models for the Intel Xeon Phi



Xeon Native

Xeon

```
...  
a[i] = b[i] * c[i]  
...
```

Offload

Xeon  
Phi

```
...  
#pragma offload  
a[i] = b[i] * c[i]  
...
```

```
...  
#pragma offload  
a[i] = b[i] * c[i]  
...
```

Xeon Phi Native

```
...  
a[i] = b[i] * c[i]  
...
```

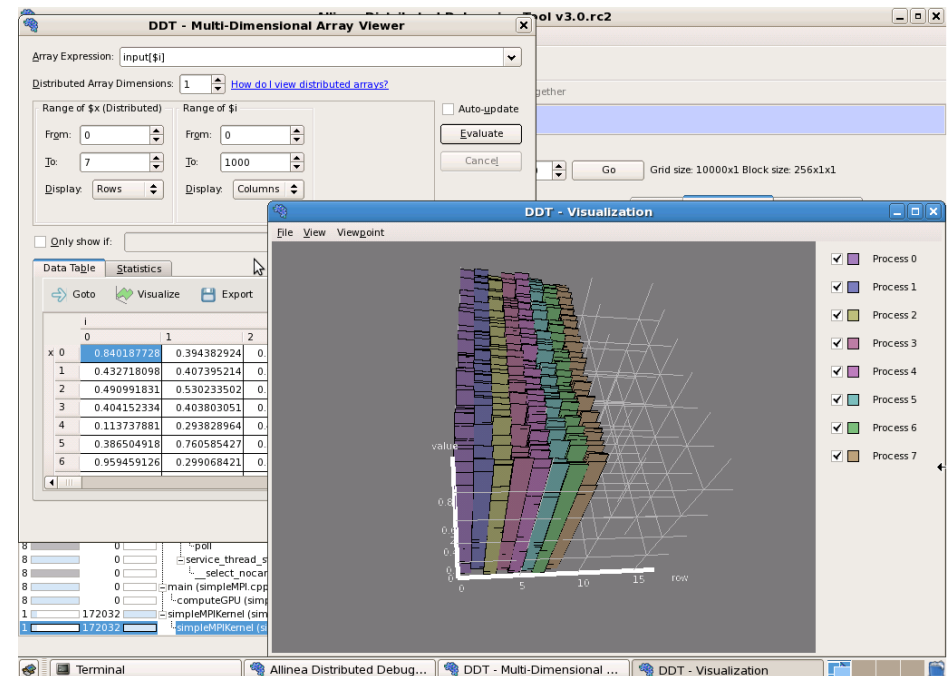
Symmetric

```
...  
a[i] = b[i] * c[i]  
...
```

```
...  
a[i] = b[i] * c[i]  
...
```

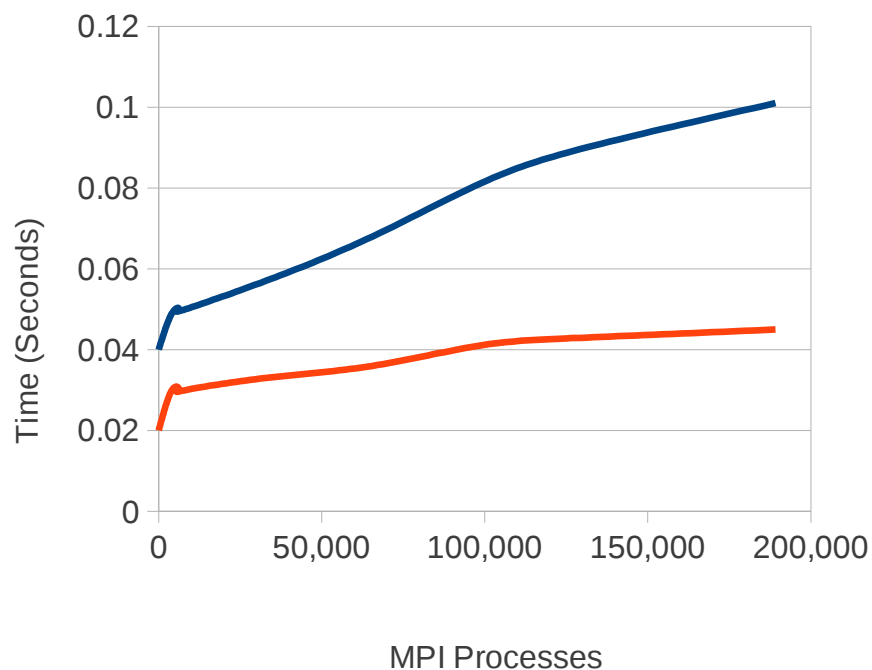
# Examining device data

- Device memory visualization
  - Inspect arrays on the device
  - Visualize within Allinea DDT
  - Join array from multiple processes



# Alinea DDT - Petascale and beyond

DDT 3.0 Performance Figures



— All Step  
— All Breakpoint

- Scale doesn't have to be **slow**
  - High performance debugging - even at 200,000 cores
  - Step all and display stacks: 0.1 seconds
  - Logarithmic performance
- Stable and in production use
  - Routinely used by end users at over 100,000 cores
- Scale doesn't have to be **hard**
  - 100,000 cores should be as easy as 100 cores
  - The user interface is vital to success

# Scalability delivered

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- Not just **on** the machine – but **on** the machine **at scale**
  - *People claimed that you could not debug beyond several hundred to several thousand processes - now my group routinely debugs parallel code at more than 100,000 processes.”*

*Rich Graham, Oak Ridge National Lab.*

- *“Collective operations to take 15 seconds at full machine size [300,000 cores]”*

*Blue Waters Statement of Work*

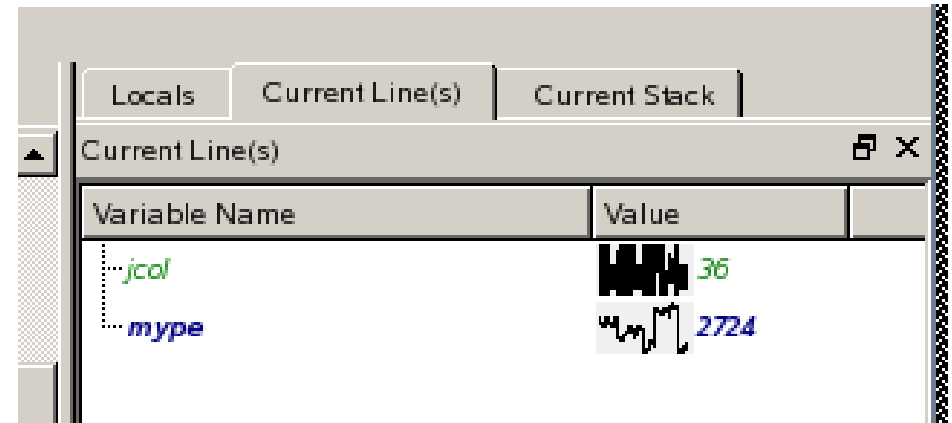
*... Allinea DDT – delivered **50-150 milliseconds**...*

- Many active customers with more than 8,000 CPU cores
- 1024 is the new 32 – and 100,000 is the new 1,000!



# Key features at scale

- Top 5 features at scale
  - Parallel stack view
    - Ideal for divergence or deadlock
  - Automated data comparison: sparklines
    - Rogue data is easily seen
  - Parallel Array searching and visualization
    - Data is too large to examine manually
  - Process control with step, play, and breakpoints
    - Still essential
  - Offline debugging
    - Access to machine may be hard – try offline debugging instead



# Allinea DDT - Debugging++

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- Productively **debug** your parallel code
- Completely **understand** your parallel code
  - Interact with data, algorithms, codes, programs and applications in real time
- **Develop** parallel your code from scratch
- **Port** parallel algorithms, codes, programs and applications to **X**
- **Scale** your algorithms, codes, programs and applications

# Clients and Collaborations



Partnership to develop Petascale debugging – delivered – and more to come!



Partnership to develop Petascale/Exascale tools and standards



Partnership for full scale debugging on IBM Blue Gene/P & /Q



**Allinea DDT** is the debugger for full scale debugging on the Blue Waters sustained petaflop machine



Partnership with CEA French Atomic Energy Authority on scalable programming and accelerators



Partnership on Keeneland project to help solving software challenges introduced by mixed architectures

# Challenges for developers

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Scale



Heterogeneity



Legacy

Diversity